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TRANSMITTAL LETTER TO THE UNITED STATES	**219809US2PCT**
DESIGNATED/ELECTED OFFICE (DO/EO/US)	U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR
CONCERNING A FILING UNDER 35 U.S.C. 371	**10/049906**

INTERNATIONAL APPLICATION NO. **PCT/JP00/04018**	INTERNATIONAL FILING DATE **20 June 2000**	PRIORITY DATE CLAIMED **none**

TITLE OF INVENTION
RELAY DEVICE

APPLICANT(S) FOR DO/EO/US
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Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.

2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.

3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include itens (5), (6), (9) and (24) indicated below.

4. ☐ The US has been elected by the expiration of 19 months from the priority date (Article 31).

5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))

    a. ☐ is attached hereto (required only if not communicated by the International Bureau).

    b. ☒ has been communicated by the International Bureau.

    c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).

6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).

    a. ☒ is attached hereto.

    b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).

7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))

    a. ☐ are attached hereto (required only if not communicated by the International Bureau).

    b. ☐ have been communicated by the International Bureau.

    c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.

    d. ☒ have not been made and will not be made.

8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).

10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).

12. ☒ A copy of the International Search Report (PCT/ISA/210).

Items 13 to 20 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.

14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

15. ☐ A **FIRST** preliminary amendment.

16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.

17. ☐ A substitute specification.

18. ☐ A change of power of attorney and/or address letter.

19. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.

20. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).

21. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).

22. ☐ Certificate of Mailing by Express Mail

23. ☒ Other items or information:

    Form PTO-1449
    Drawings (4 sheets)
    PCT/IB/308

    PCTUS1/REV03

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10/049906	PCT/JP00/04018	219809US2PCT

24. The following fees are submitted:.

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

	CALCULATIONS PTO USE ONLY

☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO $1040.00

☒ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO $890.00

☐ International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO $740.00

☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) $710.00

☐ International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) $100.00

ENTER APPROPRIATE BASIC FEE AMOUNT = $890.00

Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)). $0.00

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	4 - 20 =	0	x $18.00	$0.00
Independent claims	1 - 3 =	0	x $84.00	$0.00
Multiple Dependent Claims (check if applicable).			☐	$0.00

TOTAL OF ABOVE CALCULATIONS = $890.00

☐ Applicant claims small entity status. See 37 CFR 1.27). The fees indicated above are reduced by 1/2. $0.00

SUBTOTAL = $890.00

Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). + $0.00

TOTAL NATIONAL FEE = $890.00

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable).** ☐ $0.00

TOTAL FEES ENCLOSED = $890.00

Amount to be: refunded	$
charged	$

a. ☒ A check in the amount of ___$890.00___ to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. ___15-0030___ A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Surinder Sachar
Registration No. 34,423

22850

[signature]
SIGNATURE

Marvin J. Spivak
NAME

24,913
REGISTRATION NUMBER

Feb. 20 2002
DATE

4/PRTS   1

SPECIFICATION

TITLE OF THE INVENTION

RELAY DEVICE

5

TECHNICAL FIELD

   The present invention relates to a relay device used for terrestrial broadcasting in which both a reception frequency and a transmission frequency having the same value as each other are used.

10

BACKGROUND ART

   In a terrestrial television broadcasting system, a relay device is installed in a relay station to send out a broadcast radio wave to regions such as a mountainous region in which it is difficult to receive the broadcast radio wave. In this relay device, a broadcast radio wave transmitted from a parent station is received, amplified and again sent out.

   Also, the adoption of an orthogonal frequency division multiplex (OFDM) method is determined in Europe and Japan as a transmission method of digital terrestrial broadcasting. In this OFDM method, because a plurality of signals having the same frequency as each other can be used in an area, a single frequency network (SFN) can be used.

   Therefore, it is studied to prepare the SFN in the terrestrial digital broadcasting, and it is studied to use the reception frequency and the transmission frequency having the same value as each other in a relay device so as to efficiently use the frequency. In cases where the reception frequency and the transmission frequency in a relay device of a relay station are the same as each other, both a radio wave transmitted from a parent station and a radio wave transmitted from the relay station are received in a reception antenna of the relay

device. In this case, there is a possibility that a signal is oscillated in an amplifying unit of the relay device and a broadcast service cannot be performed.

To prevent the oscillation of the amplifying unit of the relay device of the relay station, it is required that a received electric power D of the radio wave received in the parent station and a received electric power U of a transmission radio wave (or a go-around radio wave) of the relay station satisfy a condition D>U. However, because the electric power of the radio wave transmitted from the relay device is sufficiently higher than the electric power of the radio wave received in the relay device, it is not generally easy that the condition D>U is satisfied. Therefore, various methods have been proposed to remove the go-around radio wave and to sufficiently reduce the received electric power U of the transmission radio wave of the relay station.

As a method of removing the go-around radio wave by using a reception antenna, a method of canceling-out the go-around radio wave by using a plurality of reception antennas has been proposed. Fig. 1 is a block diagram showing the configuration of a conventional relay device disclosed in Published Unexamined Japanese Patent Application No. H11-298421 (1999).

In Fig. 1, 1 indicates a main reception antenna for receiving both a radio wave (of a frequency f_1) transmitted from a parent station and a go-around radio wave of a relay station in which the relay device is installed. 2 indicates a subsidiary reception antenna for receiving the go-around radio wave of the relay station. 3 indicates a changeable attenuator for changing an amplitude of a reception signal of the go-around radio wave received in the subsidiary reception antenna 2 by a preset attenuation factor. 4 indicates a phase shifting unit (or phase shifter) for changing a phase of a signal output from the

changeable attenuator 3 by a preset shifting phase value. 5 indicates a composite signal producing unit (or composite signal producer) for producing a composite signal from both a signal of the radio wave of the parent station and a signal of the go-around radio wave received in the main reception antenna 1 and the signal sent from the phase shifting unit 4. 6 indicates an amplifying unit for amplifying the composite signal produced in the composite signal producing unit 5. 7 indicates a transmission antenna for transmitting a transmission radio wave (of the frequency f_1) of the relay station according to the composite signal amplified in the amplifying unit 6.

Next, an operation will be described below.

The main reception antenna 1 has a directivity in the direction of the parent station, and the radio wave transmitted from the parent station is received in the main reception antenna 1. Also, a go-around radio wave transmitted from the transmission antenna 7 of the relay station is mixed with the radio wave of the parent station and is received in the main reception antenna 1. A reception signal composed of a mixture of the radio wave of the parent station and the go-around radio wave is received in the composite signal producing unit 5. The subsidiary reception antenna 2 is directed towards the transmission antenna 7, and the go-around radio wave transmitted from the transmission antenna 7 of the relay station is received in the subsidiary reception antenna 2. An amplitude of a reception signal of the go-around radio wave is changed by a preset attenuation factor in the changeable attenuator 3. A phase of a signal received in the phase shifting unit 4 is changed by a preset shifting phase value, and the signal is output to the composite signal producing unit 5.

In the composite signal producing unit 5, a composite signal is produced from a signal of a mixture of the radio wave of the parent station and the go-around radio wave received in the main reception

antenna 1 and a signal of the go-around radio wave which is received in the subsidiary reception antenna 2 and of which the amplitude and the phase are adjusted. In this case, the attenuation factor of the changeable attenuator 3 and the shifting phase value of the phase

5 shifting unit 4 are set so as to produce a composite signal from a signal of the go-around radio wave received in the main reception antenna 1 and a signal of the go-around radio wave received in the subsidiary reception antenna 2 having the same amplitude as each other at phases opposite to each other. Therefore, the signal of the

10 go-around radio wave is canceled out in the composite signal, and the output of the composite signal producing unit 5 is composed of the composite signal of only the radio wave component of the parent station.

Because the conventional relay device has the above-described

15 configuration, when characteristics of the main reception antenna 1, the subsidiary reception antenna 2 and/or the transmission antenna 7 are changed due to a change of the environment caused by wind, snow or the like, the two go-around radio waves received in the composite signal producing unit 5 do not have the same amplitude as each other

20 at the phases opposite to each other. Therefore, a problem has arisen that the go-around radio wave cannot be completely removed from the composite signal.

Also, in cases where the conventional relay device is set so as to be automatically adapted for the change of the environment, it is

25 required to distinguish the go-around radio wave from the radio wave of the parent station. Therefore, as is described in the Patent Application, another problem has arisen that it is required to superpose a relay station identification signal on the transmission radio wave of the relay station transmitted from the transmission

30 antenna 7.

The present invention is provided to solve the above-described problem, and the object of the present invention is to provide a relay device in which a go-around radio wave can be canceled out without the superposition of a relay station identification signal while being

5   adapted for a change of the environment caused by wind or snow.

DISCLOSURE OF THE INVENTION

A relay device according to the present invention, in which a radio wave of a parent station is received and amplified and a transmission

10   radio wave having the same frequency as that of the radio wave of the parent station is transmitted, comprises a main reception antenna for receiving both the radio wave of the parent station and a go-around radio wave of a relay station, a subsidiary reception antenna for receiving the go-around radio wave of the relay station, a changeable

15   attenuator for changing an amplitude of a signal of the go-around radio wave received by the subsidiary reception antenna, a phase shifter for changing a phase of the signal of the go-around radio wave received by the subsidiary reception antenna, a composite signal producer for producing a composite signal from a signal of the radio wave of the

20   parent station received by the main reception antenna, the signal of the go-around radio wave of the relay station and the signal of which the amplitude is changed by the changeable attenuator and the phase is changed by the phase shifter, a directivity coupler for extracting a composite voltage of the composite signal output from the composite

25   signal producer, an electric power detector for obtaining a composite electric power from the composite voltage extracted by the directivity coupler, and a microcomputer for controlling both a change of the amplitude performed by the changeable attenuator and a change of the phase performed by the phase shifter so as to minimize an average value

30   of the composite electric power obtained by the electric power

detector.

Therefore, the go-around radio wave can be cancelled while the relay device is adapted for a change of an environment of the relay device.

The relay device according to the present invention further comprises an output controller for controlling an output of the transmission radio wave transmitted from the relay station according to an instruction of the microcomputer when the supply of an electric power is started.

Therefore, the oscillation occurring in the relay device can be suppressed when the supply of an electric power to the relay device is started.

In the relay device according to the present invention, an initial operation point of the changeable attenuator and an initial operation point of the phase shifter are automatically detected by the microcomputer by obtaining a minimum value of the composite electric power obtained by the electric power detector.

Therefore, the detection of initial operation points of both the changeable attenuator and the phase shifter performed by measuring the amplitude and phase of the go-around radio wave is not required.

The relay device according to the present invention further comprises an output controller for controlling an output of the transmission radio wave transmitted from the relay station according to an instruction of the microcomputer when an initial operation point of the changeable attenuator and an initial operation point of the phase shifter are automatically detected by the microcomputer.

Therefore, the oscillation occurring in the relay device can be suppressed during the automatic detection of the initial operation points performed by the microcomputer.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram showing the configuration of a conventional relay device.

Fig. 2 is a block diagram showing the configuration of a relay device according to a first embodiment of the present invention.

5   Fig. 3 is a view showing a characteristic of a change of an average value of a composite electric power due to a change of an attenuation factor of a changeable attenuator according to a second embodiment of the present invention.

Fig. 4 is a view showing a characteristic of a change of an average

10   value of a composite electric power due to a change of a value of a phase shifted in a phase shifting unit according to the second embodiment of the present invention.

Fig. 5 is a block diagram showing the configuration of a relay device according to a third embodiment of the present invention.

15

BEST MODE FOR CARRYING OUT THE INVENTION

Hereinafter, the best mode for carrying out the present invention will now be described with reference to the accompanying drawings to explain the present invention in more detail.

20   EMBODIMENT 1

Fig. 2 is a block diagram showing the configuration of a relay device according to a first embodiment of the present invention. In Fig. 2, 8 indicates a directivity coupling unit (or directivity coupler) for extracting a composite voltage of the composite signal output from

25   the composite signal producing unit 5. 9 indicates an electric power detecting unit (or electric power detector) for obtaining a composite electric power from the composite voltage extracted in the directivity coupling unit 8. 10 indicates a microcomputer for controlling an attenuation factor of the changeable attenuator 3 and a shifting phase

30   value of the phase shifting unit 4 so as to minimize an average value

of the composite electric power obtained in the electric power detecting unit 9. The other constitutional elements are the same as or equivalent to those of the conventional relay device shown in Fig. 1.

5   Next, an operation will be described below.

A composite voltage output from the composite signal producing unit 5 is extracted in the directivity coupling unit 8, a composite electric power is obtained in the electric power detecting unit 9 from the composite voltage extracted in the directivity coupling unit 8, and 10 the composite electric power is input to the microcomputer 10.

A voltage V_{M1} of a radio wave of a parent station received in the main reception antenna 1 is expressed according to an equation (1).

$$V_{M1} = V_d \ f(t) \tag{1}$$

In this case, a voltage V_{M2} of a go-around radio wave received in the 15 main reception antenna 1 is expressed according to an equation (2).

$$V_{M2} = V_{U1} \ e^{j\theta 1} \ f(t - \Delta t) \tag{2}$$

Here, V_d denotes an average voltage of the radio wave of the parent station, V_{U1} denotes an average voltage of the go-around radio wave received in the main reception antenna 1, $\theta 1$ denotes a phase of the 20 go-around radio wave received in the main reception antenna 1, and Δt denotes a time period from the reception of the radio wave of the parent station to the reception of the go-around radio wave in the main reception antenna 1 or the subsidiary reception antenna 2 through the processing of the radio wave in the relay device and the 25 transmission of the go-around radio wave from the transmission antenna 7. In case of a television relay device, the time period Δt is normally equal to or higher than $1\mu s$.

In the same manner, a voltage V_{s2} of a go-around radio wave received in the subsidiary reception antenna 2 is expressed according to an 30 equation (3).

$$V_{s2} = V_{U2} \ e^{j\theta 2} \ f(t - \Delta t) \tag{3}$$

Here, V_{U2} denotes an average voltage of the go-around radio wave received in the subsidiary reception antenna 2, and $\theta 2$ denotes a phase of the go-around radio wave received in the subsidiary reception antenna 2.

Therefore, the voltage V_M received in the main reception antenna 1 is expressed according to an equation (4).

$$V_M = V_{M1} + V_{M2} = V_d \ f(t) + V_{U1} e^{j\theta 1} \ f(t - \Delta t) \tag{4}$$

In cases where an amplitude of a signal corresponding to the voltage V_{s2} of the go-around radio wave received in the subsidiary reception antenna 2 is changed by α times (or an attenuation factor α) in the changeable attenuator 3 and a phase of the signal of the voltage V_{s2} is changed by ϕ (or a shifting phase value ϕ) in the phase shifting unit 4, an composite voltage V_0 output from the composite signal producing unit 5 is expressed according to an equation (5).

$$V_0 = V_d \ f(t) + (V_{U1} \ e^{j\theta 1} + \alpha \ V_{U2} \ e^{j(\theta 2 + \phi)}) \ f(t - \Delta t) \tag{5}$$

Thereafter, the composite voltage V_0 is squared in the electric power detecting unit 9 to obtain a composite electric power.

$$V_0^2 = V_d^2 \ f^2(t) + (V_{U1} \ e^{j\theta 1} + \alpha \ V_{U2} \ e^{j(\theta 2 + \phi)})^2 \ f^2(t - \Delta t)$$
$$+ 2 \ V_d \ (V_{U1} \ e^{j\theta 1} + \alpha \ V_{U2} \ e^{j(\theta 2 + \phi)}) \ f(t) \ f(t - \Delta t) \tag{6}$$

Here, when the condition $\Delta t \geqq 1 \mu s$ is satisfied, an average of $f(t) f(t - \Delta t)$ is equal to 0 due to the characteristics of the OFDM method of the terrestrial digital broadcasting. Therefore, an average value of the composite electric power is obtained according to an equation (7).

$$|V_0^2| = |V_d^2 \ f^2(t)| + |(V_{U1} \ e^{j\theta 1} + \alpha \ V_{U2} \ e^{j(\theta 2 + \phi)})^2 \ f^2(t - \Delta t)| \tag{7}$$

Here, $|a|$ denotes an average of the symbol "a". In this case, it is applicable that the average value $|V_0^2|$ of the composite electric power be obtained in the electric power detecting unit 9 and be output to the microcomputer 10. Also, it is applicable that the average value

$|V_0^2|$ of the composite electric power be obtained in the microcomputer 10.

Also, to cancel the go-around radio wave, the attenuation factor α of the changeable attenuator 3 is set according to an equation (8).

$$V_{U1} = \alpha V_{U2} \qquad \rightarrow \qquad \alpha = V_{U1}/V_{U2} \qquad (8)$$

Also, the shifting phase value ϕ of the phase shifting unit 4 is set according to an equation (9).

$$\theta 2 + \phi = \theta 1 + \pi \qquad \rightarrow \qquad \phi = \theta 1 - \theta 2 + \pi \qquad (9)$$

When the condition of the equation (9) is satisfied,

$$e^{j(\theta 2 + \phi)} = e^{j(\theta 1 + \pi)} = e^{j\theta 1} e^{j\pi} = -e^{j\theta 1}$$

is obtained. Also, when the condition of the equation (8) is satisfied, the second term of the equation (7) is equal to 0. Therefore, it is realized that the go-around radio wave is canceled out in the composite voltage output from the composite signal producing unit 5.

As is described above, in cases where the attenuation factor α of the changeable attenuator 3 and the shifting phase value ϕ of the phase shifting unit 4 are set as operation points of both the changeable attenuator 3 and the phase shifting unit 4 so as to minimize the average value $|V_0^2|$ of the composite electric power, it is realized that the relay device is set to a state of the canceling-out of the go-around radio wave.

Accordingly, in the first embodiment, in cases where the environment of the relay device is changed due to wind or snow, the attenuation factor of the changeable attenuator 3 and a degree of phase shifted in the phase shifting unit 4 are controlled by the microcomputer 10 so as to minimize the average value $|V_0^2|$ of the composite electric power. Therefore, the go-around radio wave can be canceled out while being adapted for a change of the environment. Also, in this algorithm, it is not required to superpose a relay device identification signal identifying the go-around radio wave on the transmission radio wave

of the relay station.

EMBODIMENT 2

In the first embodiment, on the assumption that initial operation

5   points of both the changeable attenuator 3 and the phase shifting unit

4 are set when the relay device is installed in the relay station,

the relay device is operated while being adapted for a change of the

environment. However, it is possible to automatically obtain the

initial operation points.

10   Fig. 3 is a view showing a characteristic of a change of the average

value $|V_0^2|$ of the composite electric power due to a change of the

attenuation factor α of the changeable attenuator 3. As shown in Fig.

3, a change of the average value $|V_0^2|$ of the composite electric power

with respect to the attenuation factor α of the changeable attenuator

15   3 is expressed by a quadratic curve, and an operation point

corresponding to the canceling-out of the go-around radio wave is

placed at a point of Fig. 3 at which the average value $|V_0^2|$ of the

composite electric power is minimized. Therefore, when the supply of

an electric power to the relay device is started, the minimum point

20   of the average value $|V_0^2|$ of the composite electric power is detected

while changing the attenuation factor α little by little by using the

microcomputer 10.

Fig. 4 is a view showing a characteristic of a change of the average

value $|V_0^2|$ of the composite electric power due to a change of the value

25   ϕ of the phase shifted in the phase shifting unit 4. As shown in Fig.

4, a change of the average value $|V_0^2|$ of the composite electric power

with respect to the shifting phase value ϕ is expressed by a cosine

curve, and an operation point corresponding to the canceling-out of

the go-around radio wave is placed at a point of Fig. 4 at which the

30   average value $|V_0^2|$ of the composite electric power is minimized.

Therefore, in the same manner as in the above case, the minimum point of the average value $|V_0^2|$ of the composite electric power is detected while changing the phase shifting value ϕ little by little by using the microcomputer 10.

5   As is described above, in the second embodiment, the initial operation point, at which the average value $|V_0^2|$ of the composite electric power is minimized, can be automatically detected. Therefore, when the relay device is installed in the relay station, it is not required to set operation points of both the changeable attenuator

10   3 and the phase shifting unit 4 by measuring the amplitude and phase of the go-around radio wave.

EMBODIMENT 3

In the first embodiment, when the relay device is installed in the

15   relay station, the initial operation points of both the changeable attenuator 3 and the phase shifting unit 4 are measured and set. However, when the supply of an electric power to the relay device is suddenly started, the go-around radio wave cannot be sufficiently canceled out due to measurement errors of the initial operation points. Therefore,

20   there is a probability that a signal oscillation occurs in the relay device.

Also, in the second embodiment, the initial operation points of both the changeable attenuator 3 and the phase shifting unit 4 are automatically detected by the microcomputer 10. However, the go-

25   around radio wave cannot be sufficiently canceled out during the detection of the initial operation points. Therefore, in the same manner, there is a probability that a signal oscillation occurs in the relay device.

Fig. 5 is a block diagram showing the configuration of a relay device

30   according to a third embodiment of the present invention. In Fig. 5,

11 indicates an output control unit (or output controller) for controlling an output of the amplifying unit 6 by using the microcomputer 10 and outputting the output of the amplifying unit 6 to the transmission antenna 7.

5   Next, an operation will be described below.

When the supply of an electric power to the relay device is started, an output of the output control unit 11 is set to zero under the control of the microcomputer 10 to control the relay device not to output a transmission radio wave from the relay device. In this case, an output

10   value of the electric power detecting unit 9 is stored in the microcomputer 10. Because no go-around radio wave is included in this output value of the electric power detecting unit 9, the output value indicates a reception level of the radio wave of the parent station. Thereafter, the output control unit 11 is controlled by the

15   microcomputer 10 so as to heighten an output level (or output value) of the relay device little by little until the output level of the relay device reaches a regular output level. Therefore, a signal oscillation occurring in the relay device can be avoided.

In this case, a threshold value is preset to a value ranging from

20   the output value stored in the microcomputer 10 to the double of the output value. When an electric power detected in the electric power detecting unit 9 is equal to or higher than the preset threshold value, operation points set in both the changeable attenuator 3 and the phase shifting unit 4 differ from optimum operation points at which the

25   average value $|V_0^2|$ of the composite electric power is minimized. Therefore, the electric power equal to or higher than the preset threshold value indicates that the go-around radio wave is not canceled out. In this case, an output of the relay device is fixed at the operation points under the control of the output control unit 11, the

30   optimum operation points are detected in the same manner as in the

case of the change of the environment, and the output of the relay device is gradually heightened.

Also, while the initial operation points of both the changeable attenuator 3 and the phase shifting unit 4 are automatically detected
5 by using the microcomputer 10, the output level of the output control unit 11 is fixed to an appropriate level, which is equal to or lower than half of the regular output level, according to an instruction sent from the microcomputer 10. In this case, because an oscillation condition for the relay device is not satisfied, a signal oscillation
10 occurring in the relay device can be avoided.

As is described above, in the third embodiment, an output level of the relay device is controlled by the output control unit 11 according to the control of the microcomputer 10. Therefore, when the supply of an electric power to the relay device is started or initial operation
15 points are automatically detected by the microcomputer 10, the oscillation occurring in the relay device can be suppressed.

INDUSTRIAL APPLICABILITY

As is described above, in a relay device according to the present invention, a transmission radio wave having the same frequency as that of a radio wave received from a parent station is transmitted.

5   Therefore, the relay device is appropriate to the canceling-out of a go-around radio wave while being adapted for a change of an environment of the relay device caused by wind or snow.

WHAT IS CLAIMED IS:

1. A relay device, in which a radio wave of a parent station is received and amplified and a transmission radio wave having the same frequency as that of the radio wave of the parent station is transmitted,

5   comprising:

a main reception antenna for receiving both the radio wave of the parent station and a go-around radio wave of a relay station;

a subsidiary reception antenna for receiving the go-around radio wave of the relay station;

10   a changeable attenuator for changing an amplitude of a signal of the go-around radio wave received by the subsidiary reception antenna;

a phase shifter for changing a phase of the signal of the go-around radio wave received by the subsidiary reception antenna;

a composite signal producer for producing a composite signal from

15   a signal of the radio wave of the parent station received by the main reception antenna, the signal of the go-around radio wave of the relay station and the signal of which the amplitude is changed by the changeable attenuator and the phase is changed by the phase shifter;

a directivity coupler for extracting a composite voltage of the

20   composite signal output from the composite signal producer;

an electric power detector for obtaining a composite electric power from the composite voltage extracted by the directivity coupler; and

a microcomputer for controlling both a change of the amplitude performed by the changeable attenuator and a change of the phase

25   performed by the phase shifter so as to minimize an average value of the composite electric power obtained by the electric power detector.

2. A relay device according to claim 1, further comprising:

an output controller for controlling an output of the transmission

30   radio wave transmitted from the relay station according to an

instruction of the microcomputer when the supply of an electric power is started.

3. A relay device according to claim 1, wherein an initial operation
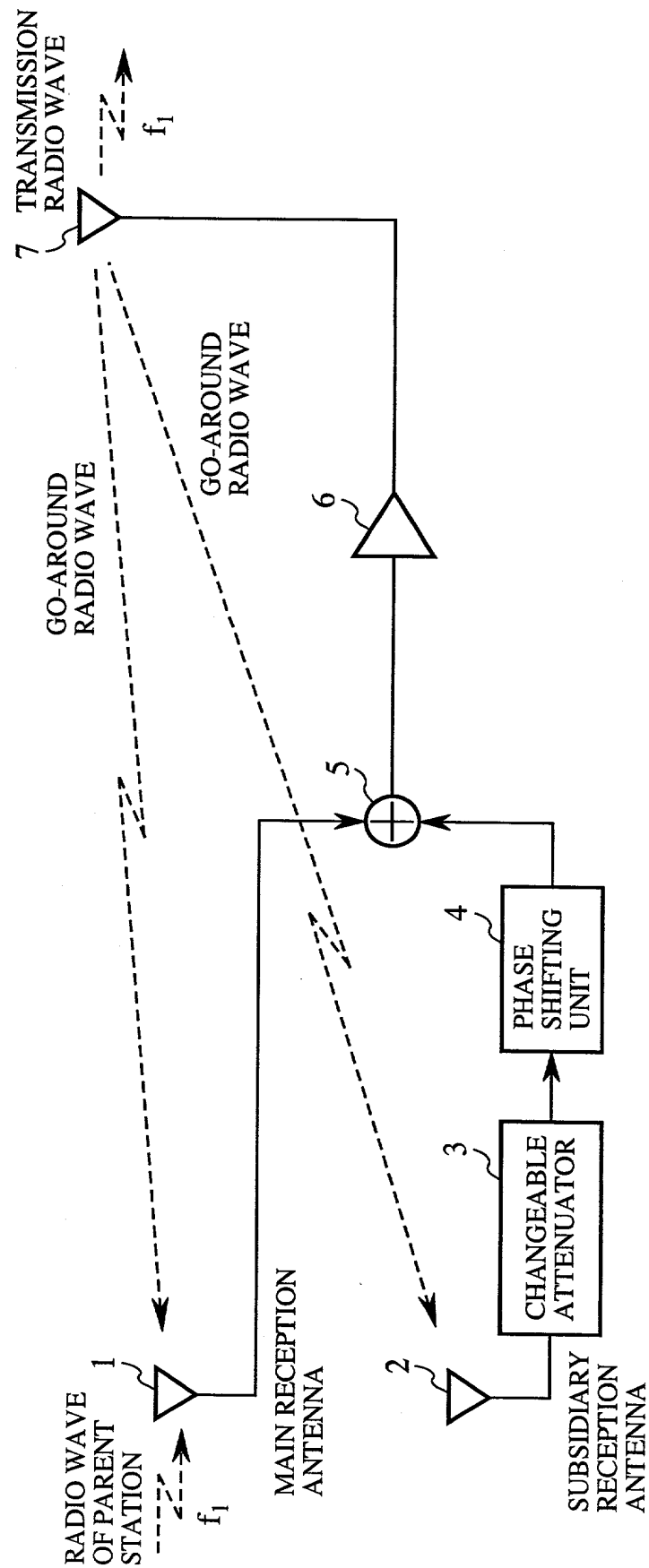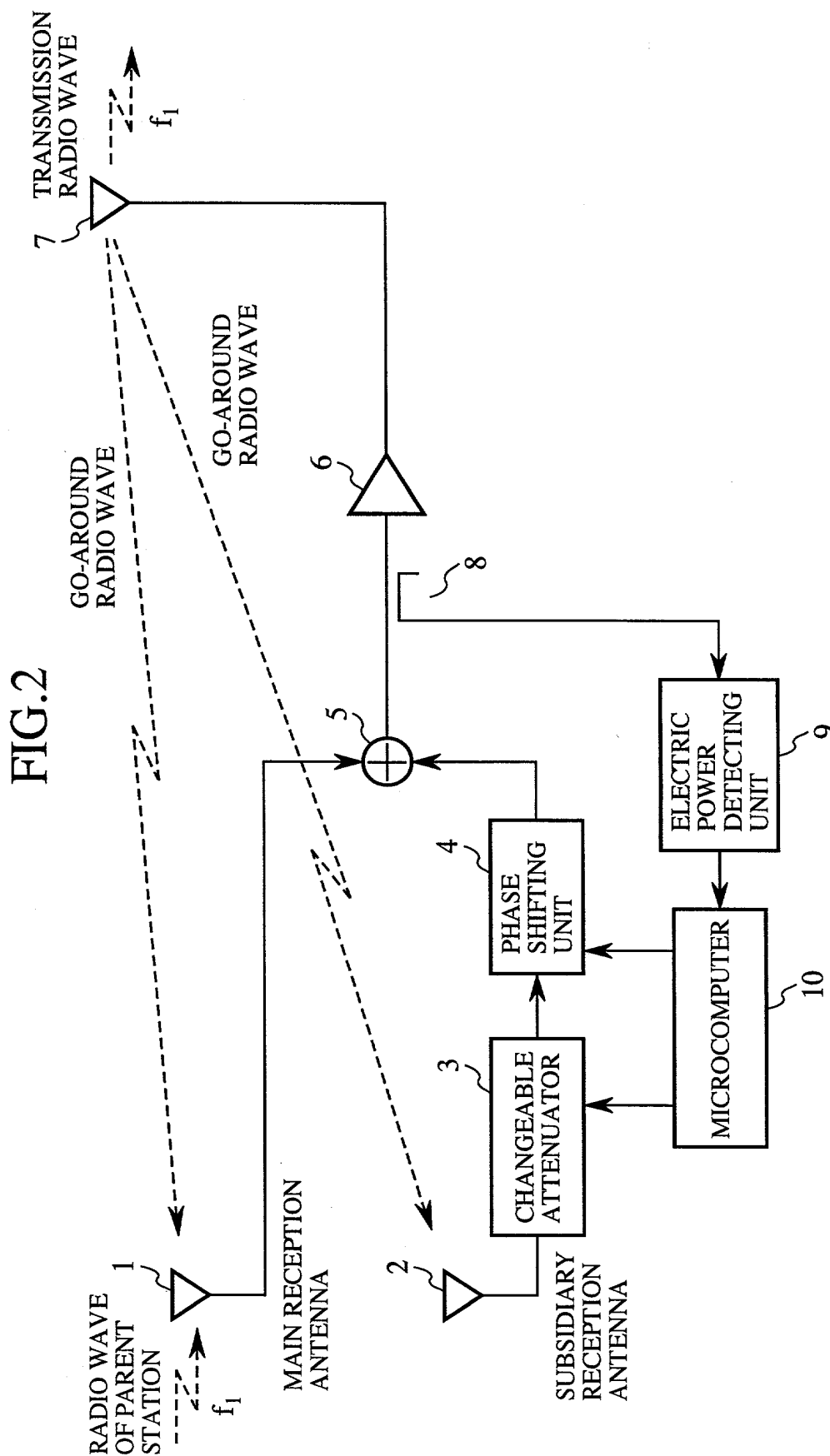5   point of the changeable attenuator and an initial operation point of the phase shifter are automatically detected by the microcomputer by obtaining a minimum value of the composite electric power obtained by the electric power detector.

10   4. A relay device according to claim 1, further comprising:
an output controller for controlling an output of the transmission radio wave transmitted from the relay station according to an instruction of the microcomputer when an initial operation point of the changeable attenuator and an initial operation point of the phase
15   shifter are automatically detected by the microcomputer.

ABSTRACT OF THE DISCLOSURE

A relay station is composed of a main reception antenna 1 for receiving both a radio wave of a parent station and a go-around radio wave of a relay station, a subsidiary reception antenna 2 for receiving the go-around radio wave of the relay station, a changeable attenuator 3 and a phase shifting unit 4 for changing an amplitude and phase of a signal received in the subsidiary reception antenna 2, a composite signal producing unit 5 for producing a composite signal from a signal received in the main reception antenna 1 and the signal sent from the phase shifting unit 4, an electric power detecting unit 9 for obtaining a composite electric power from a composite voltage extracted in a directivity coupling unit 8, and a microcomputer 10 for controlling a change of amplitude in the changeable attenuator 3 and a change of phase in the phase shifting unit 4 so as to minimize an average value of the composite electric power obtained in the electric power detecting unit 9.

FIG.1

RADIO WAVE OF PARENT STATION
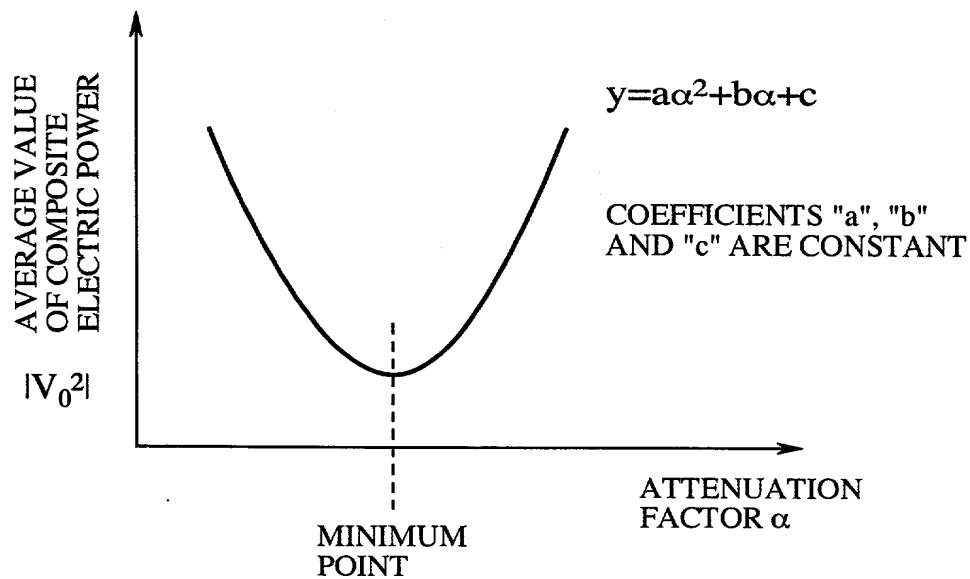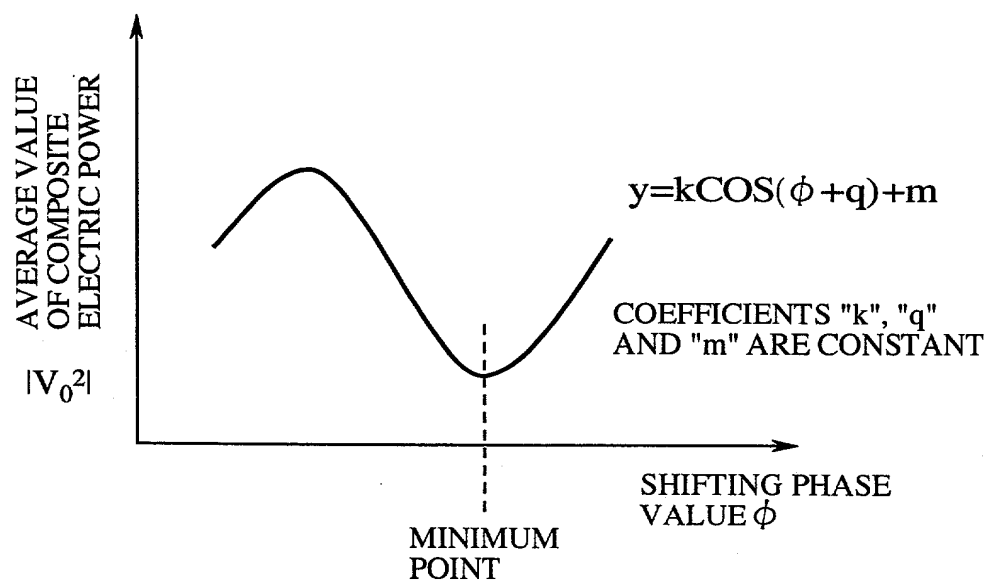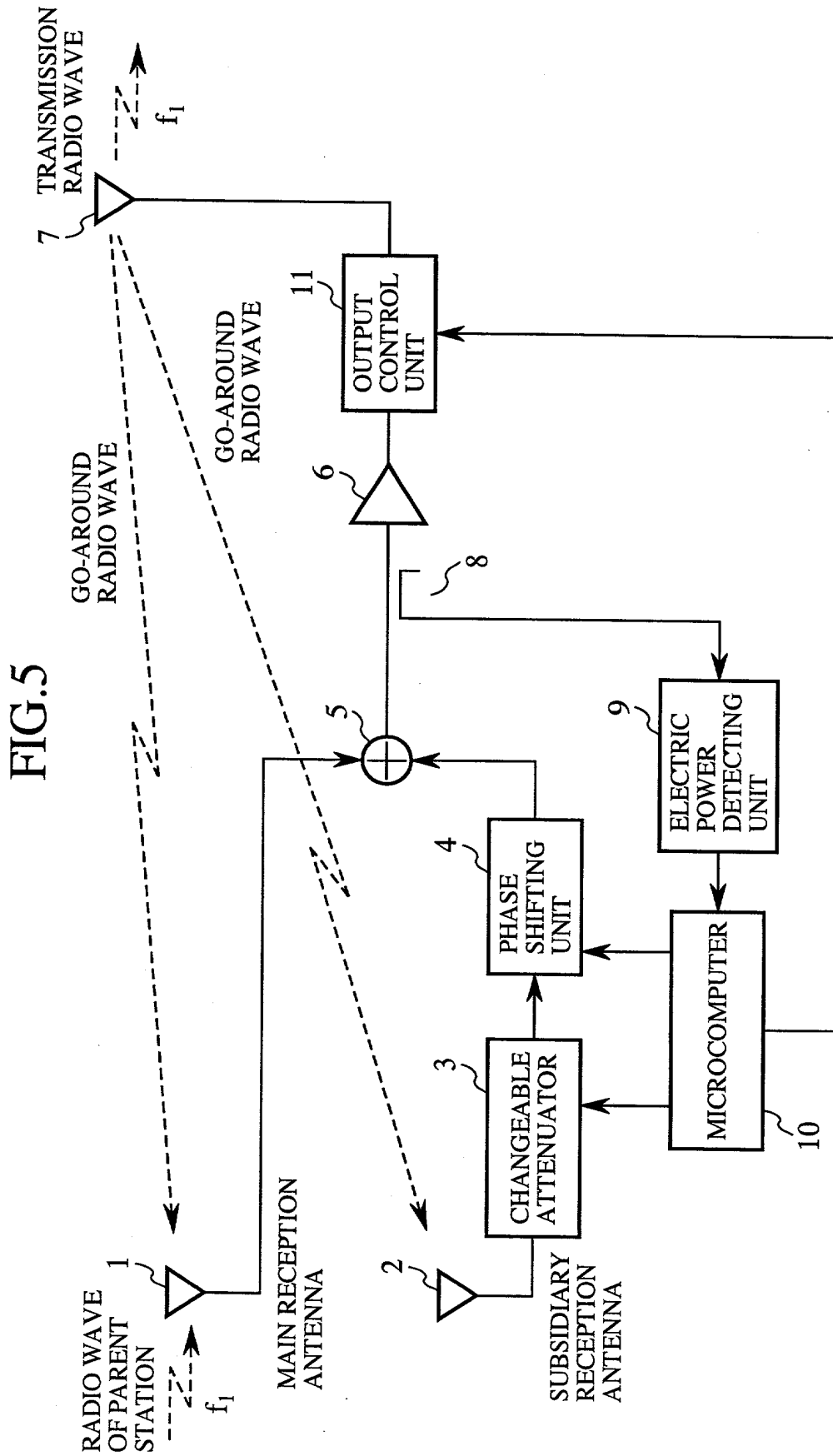
f_1

1 MAIN RECEPTION ANTENNA

2 SUBSIDIARY RECEPTION ANTENNA

3 CHANGEABLE ATTENUATOR

4 PHASE SHIFTING UNIT

5

6

7 TRANSMISSION RADIO WAVE

f_1

GO-AROUND RADIO WAVE

GO-AROUND RADIO WAVE

FIG.2

FIG.3

AVERAGE VALUE OF COMPOSITE ELECTRIC POWER

$y = a\alpha^2 + b\alpha + c$

COEFFICIENTS "a", "b" AND "c" ARE CONSTANT

$|V_0^2|$

MINIMUM POINT

ATTENUATION FACTOR α

FIG.4

AVERAGE VALUE OF COMPOSITE ELECTRIC POWER

$y = k\cos(\phi + q) + m$

COEFFICIENTS "k", "q" AND "m" ARE CONSTANT

$|V_0^2|$

MINIMUM POINT

SHIFTING PHASE VALUE ϕ

FIG.5

Declaration and Power of Attorney For Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name.

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者（下記の名称が複数の場合）であると信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled.

"RELAY DEVICE"

_____

_____

_____

上記発明の明細書は、

☐ 本書に添付されています。

☐ ____月____日に提出され、米国出願番号または特許協定条約国際出願番号を_____とし、
（該当する場合）_____に訂正されました。

the specification of which

☐ is attached hereto.

☒ was filed on June 20, 2000_____
as United States Application Number or
PCT International Application Number
PCT/JP00/04018 and was amended on
_____ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

Japanese Language Declaration
（日本語宣言書）

私は、米国法典第35編119条（a）-（d）項又は365条（b）項に基づき下記の、米国以外の国の少なくとも一ヵ国を指定している特許協力条約365（a）項に基づく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している、本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

I hereby claim foreign priority under Title 35, United States Code, Section 119 (a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or Section 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)
外国での先行出願

(Number) （番号）	(Country) （国名）	(Day/Month/Year Filed) （出願年月日）	Priority Claimed 優先権主張 ☐ Yes はい	☐ No いいえ
(Number) （番号）	(Country) （国名）	(Day/Month/Year Filed) （出願年月日）	☐ Yes はい	☐ No いいえ

私は、第35編米国法典119条（e）項に基づいて下記の米国特許出願規定に記載された権利をここに主張いたします。

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below.

(Application No.) （出願番号）	(Filing Date) （出願日）	(Application No.) （出願番号）	(Filing Date) （出願日）

私は、下記の米国法典第35編120条に基づいて下記の米国特許出願に記載された権利、又は米国を指定している特許協力条約365条（c）に基づく権利をここに主張します。また、本出願の各請求範囲の内容が米国法典第35編112条第1項又は特許協力条約で規定された方法で先行する米国特許出願に開示されていない限り、その先行米国出願書提出日以降で本出願書の日本国内または特許協力条約国際提出日までの期間中に入手された、連邦規則法典第37編1条56項で定義された特許資格の有無に関する重要な情報について開示義務があることを認識しています。

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s), or Section 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of application.

(Application No.) （出願番号）	(Filing Date) （出願日）	(Status: Patented, Pending, Abandoned) （現況：特許許可済、係属中、放棄済）
(Application No.) （出願番号）	(Filing Date) （出願日）	(Status: Patented, Pending, Abandoned) （現況：特許許可済、係属中、放棄済）

私は、私自信の知識に基づいて本宣言書中で私が行なう表明が真実であり、かつ私の入手した情報と私の信じるところに基づく表明が全て真実であると信じていること、さらに故意になされた虚偽の表明及びそれと同等の行為は米国法典第18編第1001条に基づき、罰金または拘禁、もしくはその両方により処罰されること、そしてそのような故意による虚偽の声明を行なえば、出願した、又は既に許可された特許の有効性が失われることを認識し、よってここに上記のごとく宣誓を致します。

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

8/97

Japanese Language Declaration
（日本語宣言書）

委任状：私は下記の発明者として、本出願に関する一切の手続き
を米特許商標局に対して遂行する弁理士または代理人として、
下記の者を指名いたします。
（弁護士、または代理人の指名及び登録番号を明記のこと）

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: *(list name and registration number)*

022850

書類送付先

Send Correspondence to:

022850

直接電話連絡先：（名前及び電話番号）

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第二の共同発明者の氏名	Full name of second joint inventor, if any
第二の共同発明者の署名　　　日付	Second joint Inventor's signature　　　Date
住所	Residence
国籍	Citizenship
郵便の宛先	Post Office Address

（第三以降の共同発明者についても同様に記載し、署名すること）

(Supply similar information and signature for third and subsequent joint inventors.)

1/01